

4. SURFACE AIR QUALITY ANALYZERS AND METEOROLOGICAL MEASUREMENTS

Field monitoring includes continuous measurements over several months and intensive studies that are performed on a forecast basis during selected periods when episodes are most likely to occur. The continuous measurements are made in order to assess the representativeness of the intensive study days, to provide information on the meteorology and air quality conditions on days leading up to the episodes, and to assess the meteorological regimes and transport patterns which lead to ozone episodes. The intensive study components are designed to provide a detailed aerometric database which, along with the emission estimates and continuous monitoring data, can be used to improve our understanding of the causes of pollutant episodes in the study region and to provide data for input to the models and for model evaluation. This section describes the existing routine air quality and meteorological monitoring network in southern California, and the options for continuous and intensive air quality and meteorological measurements (surface and aloft) to be made during SCOS97.

In the SCOS97 study region, the Ventura County Air Pollution Control District (VCAPCD), South Coast Air Quality Management District (SCAQMD), Mohave Desert Air Quality Management District (MDAQMD), and San Diego Air Pollution Control District (SDAPCD) are charged with the responsibility for determining compliance with state and federal air quality standards, proposing plans to attain those standards when they are exceeded, and for implementing those plans. Several agencies at the periphery of the study area (Santa Barbara Air Pollution Control District (SBAPCD), Imperial County Air Pollution Control District (ICAPCD), and the ARB) have similar responsibilities. To these ends, these agencies operate a network of sampling sites which measure ambient pollutant levels. Three types of surface air quality monitoring stations are operated by the air pollution control districts. The National Air Monitoring Stations (NAMS) were established to ensure a long term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trend analysis. The State and Local Air Monitoring Stations (SLAMS) allow state and local governments to develop networks tailored to their immediate monitoring needs. Special purpose monitors (SPM) fulfill very specific or short-term monitoring goals. SPMs are typically used as source-oriented monitors rather than monitors which reflect the overall urban air quality. Data from all three types are submitted by state and local agencies to EPA's Aerometric Information Retrieval System (AIRS), which serves as the national repository for air quality, meteorological and emissions data.

Under Title I, Section 182, of the 1990 Amendments to the Federal Clean Air Act, the EPA proposed a rule to revise the current ambient air quality surveillance regulations. The rule requires implementing a national network of enhanced ambient air monitoring stations (Federal Register, 1993). States with areas classified as serious, severe, or extreme for ozone nonattainment are required to establish photochemical assessment monitoring stations (PAMS) as part of their State Implementation Plan (SIP). In California, PAMS are required in Ventura County, and the South Coast, Southeast Desert and San Diego air basins. Each station measures speciated hydrocarbons and carbonyl compounds, ozone, oxides of nitrogen, and surface meteorological data. Additionally, each area must monitor upper air meteorology at one representative site. The VOC monitoring requirements under the PAMS program are described in Section 7. The program is being phased in over a five-year schedule, beginning in 1994, at a rate of at least one station per area per year. Intended applications for

the PAMS database include ozone and precursor trends, emission inventory reconciliation and verification, population exposure analyses, photochemical modeling support, and control strategy evaluation.

The operators of these routine measurement networks have in place or are developing quality assurance plans specific to their network or are using the operating procedures developed by the ARB. In all cases, the operating plans are reviewed and approved by the ARB. The ARB also provides regularly scheduled air quality audits of field sites and equipment.

The need for additional measurements at several locations has been identified for the SCOS97 field study. The installation and operation of these sites will be independent of the routine monitoring network.

4.1 Sampling Site Selection Criteria

There are 100 active monitoring stations in southern California. These sites have been installed at their locations to meet the needs of the local agencies. The criteria for site selection will not be discussed here.

The general locations for the supplemental monitoring sites have been chosen because they are in key locations for assessing ozone and ozone precursor transport from the Southern California Air Basin (SoCAB). Measurements at the sites will include concentrations of ozone and NO/NO_x and meteorological observations.

AeroVironment Environmental Services, Inc., (AVES) has been selected to install and operate the supplemental sites. AVES will use the following site selection criteria for the sites:

- Exposure to regional air transport
- Absence of local sources or sinks of measured species
- Adequacy to meet EPA-PSD siting criteria for air pollutant and meteorological measurements
- Availability of power and telephone
- Cost for site preparation
- Ease of access
- Security

4.2 Installation

At the supplemental sites, equipment will be installed in either available buildings at the site or in temporary shelters installed specifically for the purpose. In any event, the air quality instruments will be placed inside temperature-controlled environments with sample inlet systems and manifolds, air conditioning, instrument racks, and power distribution. Meteorological equipment will be installed on 10 meter towers at all sites. Telephone lines will be connected to the sites for regular data access and instrument checks.

4.3 Monitoring Site Locations

Table 4-1 lists the monitoring sites of the air pollution control districts and the air quality parameters measured at these sites. Of the active sites, 96 measure ozone and 81 measure NO_x. Carbon monoxide and total hydrocarbons are measured at 46 and 42 sites, respectively.

The supplemental surface air quality sites and equipment will be installed at the approximate locations given in Table 4-2.

4.4 Sampling Procedures

Sampling methods are summarized in this section. Actual operational procedures are contained in Standard Operating Procedures (SOP) of the various agencies and in the instrument manufacturers' manuals.

All the Air Pollution Control Districts measure ozone and NO/NO_x with continuous analyzers. At present, most of the NO/NO_x analyzers are operated with an inline filter made of Teflon to remove particulate matter from the ambient air before the measurement is made. For the SCOS97 study, the Teflon filters will be replaced by nylon filters (Membrana-Ghia Nylasorb) that will remove particles and nitrogen species such as nitric acid so that only NO_x is measured.

AVES will deploy continuous analyzers for the measurement of ozone and NO/NO_x concentrations at 5 supplemental sites. AVES will develop a quality assurance project plan specific to measurements at these sites that include standard operating procedures (SOPs) to describe the quality assurance/quality control plans for the project. Nylon filters (Membrana-Ghia Nylasorb) will be installed on the NO/NO_x analyzers. Teflon filters (Millipore LS 5.0 µm) will be installed on the Ozone analyzers to remove particles. Filters will be replaced once a week.

The equipment associated with the continuous air quality analyzers at the supplemental sites is summarized in Table 4-3.

Surface meteorological sensors are operated at the many of the Agency sites and will be installed at the supplemental sites. Wind speed, wind direction, temperature, and relative humidity or dew point temperature are measured at most of all sites. Solar radiation is measured at some sites. The measurements at the supplemental sites are summarized in Table 4-4.

Table 4-1
Air Quality Monitoring Sites in Southern California

Site ID	Air Basin	County	Data Source	Site Name	Variables Measured						
					O3	NO	NOx	CO	THC	CH4	NMHC
ARVN	SJVAB	Kern	CARB	ARVIN-20401 BEAR MTN BLVD	x	x	x				
BKGS	SJVAB	Kern	SJVUCD	BAKERSFIELD-1138 GOLDEN STATE	x	x	x	x	x	x	x
BLFC	SJVAB	Kern	CARB	BAKERSFIELD-5558 CALIFORNIA ST	x	x	x	x	x	x	x
EDSN	SJVAB	Kern	CARB	EDISON-JOHNSON FARM	x	x	x				x
OLDL	SJVAB	Kern	CARB	OILDALE-3311 MANOR ST	x	x	x		x	x	x
ARGR	SCCAB	San Luis Obispo	XONTEC	ARROYO GRANDE-RALCOA WAY					x	x	x
ATAS	SCCAB	San Luis Obispo	SLOCO	ATASCADERO-6005 LEWIS AVE	x	x	x				
GCTY	SCCAB	San Luis Obispo	SLOCO	GROVER CITY-9 LE SAGE DR	x	x	x				
MOBY	SCCAB	San Luis Obispo	SLOCO	MORRO BAY-MORRO BAY BL & KERN	x						
NIPO	SCCAB	San Luis Obispo	UNOCAL	NIPOMO-1300 GUADALUPE RD	x						
NPSW	SCCAB	San Luis Obispo	SLOCO	NIPOMO-148 S WILSON ST	x	x	x				
PSRB	SCCAB	San Luis Obispo	CARB	PASO ROBLES-235 SANTA FE AVE	x						
SLPL	SCCAB	San Luis Obispo	EMC	SAN LUIS OBISPO-7020 LEWIS		x	x		x		
SLOM	SCCAB	San Luis Obispo	CARB	SAN LUIS OBISPO-1160 MARSH ST	x	x	x	x	x		
CPGB	SCCAB	Santa Barbara	CHVRON	CARPINTERIA-GOBERNADOR RD	x	x	x				
ECSP	SCCAB	Santa Barbara	SBAPCD	EL CAPITAN STATE PARK	x	x	x		x		
GAVE	SCCAB	Santa Barbara	CHVRON	GAVIOTA EAST-N OF CHEVRON PLAN	x	x	x		x		
GAVW	SCCAB	Santa Barbara	CHVRON	GAVIOTA WEST-NW OF CHEVRON PLA	x	x	x		x		
GTCA	SCCAB	Santa Barbara	TEXACO	GAVIOTA-GTC A .5 MI SW OF PLT	x	x	x				
GTCC	SCCAB	Santa Barbara	TEXACO	GAVIOTA-GTC C 1 MI E OF PLANT	x	x	x		x		
GLWF	SCCAB	Santa Barbara	SBAPCD	GOLETA-380 W FAIRVIEW AVE	x	x	x	x			
LPSH	SCCAB	Santa Barbara	SBAPCD	LOMPOC-128 S 'H' ST	x	x	x	x			
LPHS	SCCAB	Santa Barbara	UNOCAL	LOMPOC-HS&P FACILITY 500 M SW	x	x	x		x		
LOSP	SCCAB	Santa Barbara	UNOCAL	LOS PADRES NF-PARADISE RD	x	x	x				
GTCB	SCCAB	Santa Barbara	TEXACO	NOJQUI PASS-GTC B HWY 101	x	x	x				
PTAR	SCCAB	Santa Barbara	UNOCAL	POINT ARGUELLO-NE OF SLC	x	x	x		x		
PTCL	SCCAB	Santa Barbara	CHVRON	POINT CONCEPTION LIGHTHOUSE	x	x	x				
SBWC	SCCAB	Santa Barbara	CARB	SANTA BARBARA-3 W. CARRILLO ST	x	x	x	x			
SMSB	SCCAB	Santa Barbara	CARB	SANTA MARIA-500 S BROADWAY	x	x	x				
SMBB	SCCAB	Santa Barbara	UNOCAL	SANTA MARIA-BATTLES BETTERAVIA	x	x	x		x		
SYAP	SCCAB	Santa Barbara	SBAPCD	SANTA YNEZ-AIRPORT RD	x						
UCSB	SCCAB	Santa Barbara	EXXON	UCSB WEST CAMPUS-ARCO TANK, IS	x	x	x		x		
VBPP	SCCAB	Santa Barbara	VBGAFF	VANDENBERG AFB-STS POWER PLANT	x	x	x	x	x		
ELRO	SCCAB	Ventura	VCAPCD	EL RIO-RIO MESA SCHOOL	x	x	x	x	x	x	x
EMMA	SCCAB	Ventura	VCAPCD	EMMA WOOD STATE BEACH	x	x	x				
THOS	SCCAB	Ventura	CARB	OAK VIEW-5500 CASITAS PASS RD	x	x	x		x		
	SCCAB	Ventura	VCAPCD	OJAI - OJAI AVENUE	x	x	x				
OJAI	SCCAB	Ventura	VCAPCD	OJAI-1768 MARICOPA HWY	x	x	x				
PRTG	SCCAB	Ventura	VCAPCD	PIRU-2SW, 2815 TELEGRAPH RD	x						
SVAL	SCCAB	Ventura	VCAPCD	SIMI VALLEY-5400 COCHRAN ST	x	x	x	x	x	x	x
TOMP	SCCAB	Ventura	VCAPCD	THOUSAND OAKS-9 2323 MOORPARK	x	x	x				
AZSA	SoCAB	Los Angeles	SCAQMD	AZUSA-803 N LOREN AVE	x	x	x	x	x	x	x
BRBK	SoCAB	Los Angeles	SCAQMD	BURBANK-228 W PALM AVE	x	x	x	x	x		x
GLDR	SoCAB	Los Angeles	SCAQMD	GLENORA-840 LAUREL	x	x	x				
HAWH	SoCAB	Los Angeles	SCAQMD	HAWTHORNE-5234 W. 120TH ST	x	x	x	x			
NLGB	SoCAB	Los Angeles	SCAQMD	LONG BEACH-3648 N LONG BEACH	x	x	x	x	x	x	x
LANM	SoCAB	Los Angeles	SCAQMD	LOS ANGELES-1630 N MAIN ST	x	x	x	x	x	x	x
LYNW	SoCAB	Los Angeles	SCAQMD	LYNWOOD-11220 LONG BEACH BLVD	x	x	x	x	x	x	
PDSW	SoCAB	Los Angeles	SCAQMD	PASADENA-752 S. WILSON AVE	x	x	x	x			

Table 4-1 Continued
Air Quality Monitoring Sites in Southern California

Site ID	Air Basin	County	Data Source	Site Name	Variables Measured						
					O3	NO	NOx	CO	THC	CH4	NMHC
PICO	SoCAB	Los Angeles	SCAQMD	PICO RIVERA-3713 SAN GABRIEL	x	x	x	x	x		x
POMA	SoCAB	Los Angeles	SCAQMD	POMONA-924 N. GAREY AVE	x	x	x	x	x		x
RSDA	SoCAB	Los Angeles	SCAQMD	RESEDA-18330 GAULT ST	x	x	x	x	x		
	SoCAB	Los Angeles	SCAQMD	SAN DIMAS-GLADSTONE (open by 1/96)	x	x	x				
CLAR	SoCAB	Los Angeles	SCAQMD	SANTA CLARITA-SAN FERNANDO RD	x	x	x	x			
VALA	SoCAB	Los Angeles	SCAQMD	W LOS ANGELES-VA HOSPITAL	x	x	x	x	x	x	
ANAH	SoCAB	Orange	SCAQMD	ANAHEIM-1610 S HARBOR BLVD	x	x	x	x	x		
CMMV	SoCAB	Orange	SCAQMD	COSTA MESA-2850 MESA VERDE DR	x	x	x	x			
ELTR	SoCAB	Orange	SCAQMD	EL TORO-23022 EL TORO RD	x	x	x	x	x		
LHAB	SoCAB	Orange	SCAQMD	LA HABRA-621 W. LAMBERT	x	x	x	x	x		
HEMT	SoCAB	Riverside	SCAQMD	HEMET-880 STATE ST	x						
LELS	SoCAB	Riverside	SCAQMD	LAKE ELSINORE-506 W FLINT ST	x	x	x				
	SoCAB	Riverside	SCAQMD	MIRA LOMA-BELLEGRIVE AVE (by 1/96)	x						
PERR	SoCAB	Riverside	SCAQMD	PERRIS-237 .5 N "D" ST	x						
RIVM	SoCAB	Riverside	SCAQMD	RIVERSIDE-7002 MAGNOLIA AVE		x	x	x	x		
RUBI	SoCAB	Riverside	SCAQMD	RUBIDOUX-5888 MISSION BLVD	x	x	x	x	x	x	
TCCC	SoCAB	Riverside	SCAQMD	TEMECULA-COUNTY CENTER	x	x	x	x			
UCDC	SoCAB	Riverside	RIVER	UC RIVERSIDE-4919 CANYON CREST	x						
LGRE	SoCAB	San Bernardino	SCAQMD	CRESTLINE-LAKE GREGORY-LAKE DR	x						
FONT	SoCAB	San Bernardino	SCAQMD	FONTANA-14360 ARROW BLVD	x	x	x				
	SoCAB	San Bernardino	SCAQMD	LAKE ARROWHEAD (Open by 1/96)	x	x	x				
RDLT	SoCAB	San Bernardino	SCAQMD	REDLANDS-DEARBORN	x						
SANB	SoCAB	San Bernardino	SCAQMD	SAN BERNARDINO-24302 4TH ST	x	x	x	x			
UL	SoCAB	San Bernardino	SCAQMD	UPLAND	x	x	x				
CLXC	SEDAB	Imperial	ICAPCD	CALEXICO-900 GRANT ST	x	x	x				
CALE	SEDAB	Imperial	CARB	CALEXICO-CALEXICO HS ETHEL ST	x	x	x	x			x
EC9S	SEDAB	Imperial	ICAPCD	EL CENTRO-150 9TH ST	x						
WEST	SEDAB	Imperial	ICAPCD	WESTMORLAND-202 W FIRST ST	x						
MOJP	SEDAB	Kern	CARB	MOJAVE-923 POOLE ST	x	x	x				
LANC	SEDAB	Los Angeles	SCAQMD	LANCASTER-315 W. PONDERA ST	x	x	x	x			x
BANN	SEDAB	Riverside	SCAQMD	BANNING-135 N ALLESANDRO	x				x		x
INDO	SEDAB	Riverside	SCAQMD	INDIO-46-990 JACKSON ST	x						
PALM	SEDAB	Riverside	SCAQMD	PALM SPRINGS-FS 590 RACQUET CL	x	x	x	x	x		x
BARS	SEDAB	San Bernardino	MDAQMD	BARSTOW-401 MOUNTAIN VIEW	x	x	x	x			
HESP	SEDAB	San Bernardino	MDAQMD	HESPERIA-17288 OLIVE ST	x	x	x	x			
JOSH	SEDAB	San Bernardino	NPS	JOSHUA TREE NATIONAL MONUMENT	x						
PHEL	SEDAB	San Bernardino	MDAQMD	PHELAN-BEEKLEY & PHELAN RDS	x	x	x	x			
TRNA	SEDAB	San Bernardino	MDAQMD	TRONA-83732 TRONA ROAD	x	x	x				
29PM	SEDAB	San Bernardino	MDAQMD	TWENTYNINE PALMS-6136 ADOBE DR	x	x	x	x			
VICT	SEDAB	San Bernardino	MDAQMD	VICTORVILLE-14029 AMARGOSA RD	x	x	x	x			
ALPN	SDAB	San Diego	SDAQMD	ALPINE-2300 VICTORIA DR	x	x	x		x	x	
CHVT	SDAB	San Diego	SDAQMD	CHULA VISTA-80 E "J" ST	x	x	x	x	x		x
DMMC	SDAB	San Diego	SDAQMD	DEL MAR-MIRACOSTA COLLEGE	x						
ECAJ	SDAB	San Diego	SDAQMD	EL CAJON-1155 REDWOOD AVE	x	x	x	x	x	x	x
ESCO	SDAB	San Diego	SDAQMD	ESCONDIDO-600 E. VALLEY PKWY	x	x	x	x	x		x
OCEA	SDAB	San Diego	SDAQMD	OCEANSIDE-1701 MISSION AVE	x	x	x	x	x		
OTAY	SDAB	San Diego	SDAQMD	OTAY-1100 PASEO INTERNATIONAL	x	x	x	x			
SDUN	SDAB	San Diego	SDAQMD	SAN DIEGO-1133 UNION ST				x			
SD12	SDAB	San Diego	SDAQMD	SAN DIEGO-330A 12TH AVE	x	x	x	x	x	x	x
SDOV	SDAB	San Diego	SDAQMD	SAN DIEGO-5555 OVERLAND AVE	x	x	x	x	x	x	x

Table 4-2
Locations for Supplemental Surface Air Quality Sites

Location	Measurement Purpose	Approximate Latitude	Approximate Longitude	Approximate Elevation (m)
Santa Catalina Island, Airport	Transport from SoCAB aloft	33°25' N	118°25' W	480
Santa Catalina Island, Avalon	Transport from SoCAB near surface	33°20' N	118°20' W	5
Palos Verdes	Transport from coast out to sea	33°35' N	118°25' W	10
Calabasas	Transport to northeast end of SoCAB	34°10' N	118°40' W	300
Cajon Pass	Transport to Lucerne Valley and Mojave Desert	34°20' N	117°30' W	1200

Table 4-3
Air Quality Equipment at Supplemental Surface Sites

Equipment	Measurement Method	Instrumentation	Operating Range
Ozone	UV Photometry	Dasibi Model 1003AH	0 to 500 ppb
NO/NO ₂ /NO _x	Chemiluminescent	TEI Model 42	0 to 500 ppb
Calibration System	Mass flow meter dilution with ozone/NO GPT	Dasibi 5008 CSI 1700	Full range of instruments
	Ozone transfer standard	Dasibi 1003RS	
	In station systems: Metering valve dilution	ML8500	
Data Logger	Digital data acquisition system	Campbell CR10 Campbell 21X	Full range of instruments
Station	Catalina, Airport: To be determine Catalina, Avalon: To be determine Palos Verdes: To be determine Calabasas: To be determine Cajon Pass: To be determine		

Table 4-4
Meteorological Equipment at Supplemental Sites

Equipment	Measurement Method	Instrumentation	Operating Range
Wind Speed as Scalar Wind Speed	Propeller	RM Young Wind Monitor-AQ and -RE	0 to 50 m/s
Wind Direction as Unit Vector Wind Direction	Attached Vane	RM Young Wind Monitor-AQ and -RE	0 to 360°
Sigma Theta	Yamartino method	Campbell DAS	0 to 100°
Temperature	Thermistor	Vaisala HMP35C	-40 to 50 °C
	Thermistor	Fenwal UUT51J1	
Relative Humidity	Capacitive device	Vaisala HMP35C	0 to 100%
	Resistive device	Phys-Chem PCRC11	
Solar Radiation	Pyranometer	LiCor LI-200SZ	0-1500 w/m ²
Data Logger	Digital data acquisition system	Campbell CR10 Campbell 21X	Full range of instruments

4.4.1 Ozone

The Air Pollution Control Districts measure ambient ozone concentrations with instruments made by several different manufacturers. All analyzers employ the UV photometric technique to determine ozone concentration. All analyzers have been designated as EPA Equivalent Methods. The following analyzers are deployed in the networks:

Thermo Environmental Inc., model 49
Dasibi Environmental, model 1003
Advanced Pollution Instrumentation, Inc., model 400

At the supplemental sites, Dasibi model 1003AH ozone analyzers will be used.

The general methods for measurement for the different analyzers are similar. The analyzers consist of a sample chamber illuminated with a continuous ultraviolet (UV) lamp with frequency at 394 nm. The air sample is first introduced to the chamber after passing through a molybdenum oxide scrubber to catalytically convert ozone to oxygen. A sensing system measures the amount of radiation that passes through the chamber without ozone in it. Then the sample is introduced to the chamber with ambient ozone in it. The difference between the UV light passing through the chamber without ozone and with ozone is proportional to the amount of ambient ozone. Some analyzers also contain sensors to measure temperature and pressure in the sample chamber so that ozone readings can be referenced to ambient conditions. Other analyzers require the measurements to be referenced to fixed conditions as determined by the average absolute pressure and temperature in the analyzer sample chamber so that ozone concentrations are given at approximately ambient conditions.

4.4.2 Oxides of Nitrogen

The Air Pollution Control Districts measure ambient NO/NO_x concentrations with instruments made by several different manufacturers. These analyzers measure the concentration of nitric oxide (NO) and total oxides of nitrogen (NO_x) by a chemiluminescence method and nitrogen dioxide (NO₂) by difference between NO_x and NO. Each analyzer has been designated as an EPA Reference Method. The following analyzers are deployed in the networks:

Thermo Environmental Inc., model 14B/D
Thermo Environmental Inc., model 42
Advanced Pollution Instrumentation, Inc., model 200A

At the supplemental sites, TEI Model 42 NO/NO_x analyzers will be used.

When NO and ozone are mixed, a gas-phase reaction occurs that produces a characteristic luminescence with an intensity that is linearly proportional to the concentration of NO. A photomultiplier tube senses the luminescence generated by the reaction. Other oxides of nitrogen can also be measured by first reducing them to NO with a molybdenum converter heated to 325 °C and then measuring the result by chemiluminescence as NO_x. The analyzer switches between measuring NO and NO_x and electronically computes difference between NO_x and NO. The difference can in some cases be attributed to NO₂ as the other major constituent of NO_x. The instruments converter can also convert other nitrogenous species, such as nitric acid and PAN, to NO. Nitric acid and nitrate particles can be removed from the sample by installing a nylon filter on the sample inlet.

4.4.3 Wind Speed Sensor

Wind speed is measured by cup or propeller anemometers of several manufacturers and models. As the cup or propeller turns a pulse is generated by a magnetic or optical switch or a direct voltage is generated by a small electrical generator. The frequency of the pulses or the generated voltage is proportional to the wind speed. The manufacturers supply relations between wind speed and rotation rate for their sensors. The sensors using a propeller are generally combined with a moveable vane to align with the wind. The cups rotate about a vertical shaft have an omnidirectional response to the wind. The following sensors are found in the study area:

Met One, model 010 and 014
Climatronics, model F460
R.M. Young, model Wind Monitor-AQ, Wind Monitor-RE
Bendix Aerovane

The supplemental sites will use R.M. Young, model Wind Monitor-AQ and Wind Monitor-RE sensors.

4.4.4 Wind Direction Sensors

Wind direction is measured with a vane that aligns itself along the direction of the wind. The orientation of the vane relative to a fixed direction, generally true north, is measured by the voltage across a potentiometer and is proportional to the angle of the vane. The following sensors are found in the study area:

Met One, model 020 and 024
Climatronics, model F460
R.M. Young, model Wind Monitor-AQ, Wind Monitor-RE
Bendix Aerovane

The supplemental sites will use R.M. Young, model Wind Monitor-AQ and Wind Monitor-RE sensors.

4.4.5 Temperature Sensor

Temperature at the sampling sites is measured with a thermistor, a platinum resistance thermometer, or a thermocouple. The thermistor and RTD are both resistance devices that respond proportionally to temperature with a voltage output that is proportional to temperature. The thermocouple develops a voltage proportional to temperature because of the proximity of dissimilar metals. A data acquisition system linearizes the voltage output for these sensors. The sensors are installed in radiation shields to reduce the effect of direct solar radiation. The shields are either mechanically aspirated with a small blower or naturally aspirated by air movement around the sensor.

The supplemental sites will use Vaisala model HMP35C temperature/relative humidity sensors. The temperature sensor is a thermistor.

4.4.6 Relative Humidity/Dew Point Sensor

The relative humidity or dew point is measured at some sites. Relative humidity is measured with capacitance or resistive devices having thin polymer films that change characteristics as water is absorbed. Dew point is measured with a chilled mirror sensor or LiCl dew cell with a heated wire-wound bobbin that absorbs water vapor and releases water vapor in proportion to the dew point.

The supplemental sites will use Vaisala model HMP35C temperature/relative humidity sensors. The relative humidity sensor is a capacitive device.

4.4.7 Solar Radiation Sensor

Solar radiation at most sampling sites is measured with LiCor model LI-200SZ pyranometers. This sensor consists of a silicon photodiode that responds to light over the range that includes visible spectrum. When calibrated and orientated properly, the sensor has an output that is proportional to the incoming solar radiation, both direct and diffuse. Some sites use Epply thermopile sensors that generate a voltage by differential heating of white and black materials.

4.5 Calibration Procedures and Frequency

Calibration procedures are described in the following section. Specific instructions are contained in available QA Plans in the form of standard operating procedures and in the manufacturers' manuals.

The Air Pollution Control Districts have routine calibration procedures that include multipoint calibrations of the ozone and NO/NO_x analyzers when instruments are installed or repaired.

At the supplemental sites, multipoint calibrations of the continuous air quality analyzers for ozone and NO/NO_x will be performed at the start and end of the study, following a zero and/or span adjustment necessitated by out-of-tolerance zero/span checks, and after instrument repair.

In addition to calibrations, routine site visits are made to each site by field technicians on a regular schedule at least once a week but usually daily. The technicians have been trained to follow procedures setup by the APCD or by AVES. Automated zero/span checks are performed every night at most sites. Manual precision checks are made once a week at many sites.

Site visits are used to ensure that all equipment are operating properly, to identify instrument problems and to give warning of developing problems.

Station checks are performed each site visit following the steps prescribed on station check forms.

Each site visit, the site technician visually inspects the meteorological sensors, the ambient air sampling probe and inlet system, and the air sampling systems.

All visits are documented. Copies of recorded data and documentation are returned at specified intervals, generally once a month, to the agency office for processing.

Quality control checks consist of periodic zero/span checks and precision checks. In both cases, test atmospheres are introduced to the analyzer operating in its normal sampling mode through a solenoid valve controlled by the site DAS. Test gases pass through all filters, scrubbers, conditioners, and other components used during normal sampling.

At many sites, each air quality analyzer is subjected to an automated zero/span check once a night. Test gases at zero and one span concentration are introduced to each analyzer. The span gas concentration is about 80% of the analyzer's nominal operating range. Zero/span data are used to determine if an analyzer needs adjustment and to evaluate validity of data. Zero/span data are accessed by telephone along with the ambient data and are reviewed daily. The following criteria are used in evaluating the data:

- Zero checks: Daily check should be within $\pm 2\%$ of full scale from the zero value established during calibration. If two consecutive zeros exceed $\pm 2\%$, the instrument is removed from service, the problem corrected, and the instrument recalibrated and returned to operation. If the check exceeds $\pm 3\%$, the instrument is immediately taken off line, given a "before" calibration, fixed, and given an "after" calibration. If the check exceeds $\pm 5\%$, the instrument has serious problems and data is invalidated. The same action as the 3% criteria is done.
- Span checks: Daily check (about 80% of full scale) should be within $\pm 10\%$ of span value established during calibration. If two consecutive spans exceed $\pm 10\%$, the instrument is removed from service, the problem corrected, and the instrument recalibrated and returned to operation. If the check exceeds $\pm 15\%$, the instrument is immediately taken off line, given a "before" calibration, fixed, and given an "after" calibration. If the check exceeds $\pm 25\%$, the instrument has serious problems and data is invalidated. The same action as the 15% criteria is done.

At some sites, the technician performs a manual precision check once a week. For this, gas with concentration between 80 and 100 ppb is introduced to the analyzer. The response of the analyzer is entered on the log sheet. Precision checks are made before any instrument adjustments or recalibrations are done. Procedures for calibration, zero/span, and precision checks are summarized in the following sections.

4.5.1 Ozone

The ozone transfer standard and clean air system are taken to the monitoring site. Ozone-free air is generated by passing ambient air through a desiccant and activated charcoal and a desiccant. The ozone transfer standard has an internal ozone generator that supplies ozone to the instrument to be calibrated and its own measurement chamber.

First, ozone-free air from the dilution system is introduced to the instrument to obtain the zero level. Then, up to five concentrations of ozone are supplied to the analyzer ranging from 10% to 90% of the analyzer range with one near the span point of 450 ppb and one near the precision point of 100 ppb. The test gases are delivered to the analyzer's sample inlet via a Teflon tube to reduce losses of ozone. This tube contains a Teflon vent to allow excess flow escape and maintain the inlet at

atmospheric pressure. Test gas passes through as much sample tubing as possible including any filter normally associated with the sampling process.

Readings from the calibrator display and primary site DAS are recorded on a calibration form and a least-squares linear regression between DAS and calibrator readings is computed. The regression for a valid calibration has a slope of 1.000 ± 0.01 , an intercept of 0.0 ± 0.01 , a regression coefficient of at least 0.999. Instruments exceeding these tolerances require further checking and possibly repair or replacement.

The ozone transfer standards are calibrated approximately once a quarter with a laboratory transfer standard. The laboratory standard verified annually with the long-path UV Photometer at the California Air Resources Board in Sacramento, CA.

4.5.2 Oxides of Nitrogen

The calibration standards consists of a dilution flow metering system, NO/NO_x-free dilution air (zero air) system, and a cylinder of compressed gas containing a known amount of NO. The manually operated dilution system contains one flow controller (mass or volumetric) to meter accurate amounts span gas, a second flow controller (mass or volumetric) to meter accurate amounts of dilution air, and a Teflon-lined or glass mixing chamber. The dilution air is generated by forcing ambient air through desiccant, Purafil, and activated charcoal. Purafil (potassium permanganate) oxidizes NO to NO₂ which is then removed by the charcoal. A cylinder of compressed gas provides a source of approximately 50 ppm NO in a balance of nitrogen. The dilution system also has a section that produces a known concentration of NO₂ by performing a gas phase titration (GPT) in which O₃ is mixed with NO to generate NO₂.

Zero and up to five upscale concentrations of NO are introduced to the instrument. The concentrations of NO range from 10% to 90% of the analyzer range with one near the span point of 450 ppb and one near the precision point of 100 ppb. Delivery to the analyzer is through as much sample line as possible including the switching solenoid valve and any inline filters.

Readings from the analyzer display and primary DAS for NO and NO_x are recorded and linear regressions of sampler versus calibrator NO and NO_x are computed. For linear operation of the analyzer, the computed regression coefficient should be at least 0.999.

The NO₂ channel response and the efficiency of the NO_x to NO converter are tested with NO₂ generated in the GPT section of the dilution system. These tests are done at 3 different NO₂ and NO_x concentrations while the NO concentration remains between 80 to 100 ppb. NO gas with concentrations for the three points are near 450, 300, and 150 ppb. The responses of the NO and NO_x channels to this NO are recorded and adjusted by the linear regression equations relating instrument response to calibration concentration. Ozone is mixed with the NO to generate NO₂ concentrations near 350, 200, and 50 ppb which are introduced to the instrument. The responses of NO and NO_x are recorded and corrected for the calibration results.

For each test, the response of the NO₂ channel is compared to the NO₂ concentration generated by the GPT as determined from

$$\text{GPT NO}_2 = \text{Orig NO} - \text{Rem NO}$$

where: Orig NO is adjusted response of NO channel before O₃ is mixed and
Rem NO is adjusted response of NO channel after O₃ is mixed.

The converter efficiency, Conv Eff, is determined in the following steps:

$$\text{_NO}_x = \text{Orig NO}_x - \text{Rem NO}_x$$

$$\text{Conv NO}_2 = \text{GPT NO}_2 - \text{_NO}_x$$

$$\text{Conv Eff} = 100 \times (\text{conv NO}_2) / (\text{GPT NO}_2)$$

where: Orig NO_x is adjusted response of NO_x channel before ozone is mixed and
Rem NO_x is adjusted response of NO_x channel after ozone is mixed.

An overall converter efficiency is calculated by averaging the efficiencies at the three levels. A converter efficiency less than 96% indicates that the converter material should be replaced.

4.5.3 Wind Speed

The wind speed sensors are calibrated one to two times a year when routine maintenance is done on the sensors, such as replacement of bearing. Known rotation rates are applied to the sensors while monitoring the DAS reading. Variable or fixed rate motors are attached to the anemometer in place of propeller or cups and the sensor shaft is turned at known angular speeds. DAS wind speeds are compared to the values supplied by the manufacturer of the sensor for known rotation rates.

Bearings are checked before calibration to determine if they affected the wind speed data before replacement. Rotation of shaft is checked for smoothness of operation and starting torque is measured with a torque wheel. For the RM Young Wind Monitors, bearings are replaced if a sensor fails to respond to a 0.3 g-cm torque.

4.5.4 Wind Direction

The wind direction sensors are calibrated one to two times a year using an angle calibrator. With the sensor in place on the calibrator and connected to the DAS, the vane is moved around the 360° circle in 10° increments. The DAS readings are compared to the calibrator angles. Sensors that have readings within ±2° of calibrator are used without correction. Sensors outside that limit are inspected for problems or used with an correction developed from the calibration.

4.5.5 Temperature

Temperature sensors that can be immersed in water are calibrated one to two times a year using water baths over the range of the sensor. Low temperature is obtained with an ice bath. Higher temperatures are reached by heating the bath with an immersion heater. A calibration thermometer with NIST-traceability should be used to measure the bath temperature. The error associated with this method is less than ± 0.5 °C.

For temperature sensor than cannot be immersed in water, the calibration can be checked by placing an aspirated, NIST-traceable thermometer near the sensor and comparing the site sensor reading to the calibration thermometer. The side-by-side calibration check can have an error of about ± 1 °C when done outdoors because of the effect of solar radiation.

4.5.6 Relative Humidity/Dew Point

The calibration of the relative humidity/dew point sensor is checked by placing the sensor in chambers containing different saturated salt solutions. These solutions give relative humidities that depend on the salt and the temperature. The range of relative humidity for typical salts is about 12% for LiCl to 97% for K₂SO₄. This calibration is best done in controlled environment and not outdoors.

The calibration can be checked in the field by placing a separate relative humidity sensor or an aspirated, psychrometer with NIST-traceable thermometers near the sensor. As with the temperature check, the psychrometer should be shaded from direct solar radiation while being exposed to the free-air. Simultaneous readings from the sensor and the wet- and dry-bulb thermometers of the psychrometer are recorded. The relative humidity is determined from psychrometric tables or a psychrometric slide rule.

4.5.7 Solar Radiation

The calibration of the solar radiation sensors is best done by returning the sensor to the manufacturer on a routine schedule. A secondary check of the sensor can be made with a side-by-side comparison between the site pyranometer and a similar pyranometer that is only used for comparison. This comparison sensor is placed as near to and with similar exposure as the site pyranometer for a several hour period. A comparison of the readings of the two pyranometers gives an indication of the operating characteristics of the site sensor.

4.6 Systems Audits

Formal, in-depth systems audits will not be conducted for the air quality and meteorological sites. Personnel from Quality Assurance Section (QAS) of the ARB will complete Comprehensive Site Surveys during site visits. The Site Survey is a qualitative evaluation of the sampling site and its operation.

Each Site Survey will be conducted by completing a standard form specific, which will consist of the following tasks:

- Document site location, measurements at site including instrument type, sampling purpose, and applicable measurement scale.
- Describe vicinity of site within 100 m radius including heights of sensors, length of probes, and towers.
- Describe obstacles near site including direction, distance, height, distance to tree dripline, distance to walls, and arc for free air flow.
- Describe nearby sources including distance and direction for flues, non-vehicular local sources, and traffic. Give dominant influence category.
- Describe the ambient air delivery system to analyzers including inlet probe, sample manifold, and tubing to instruments. Include composition, inside diameters, lengths, and flow rates. Determine probe and total residence times.
- Determine if approved QA Plan is used, schedule for cleaning, auto-calibration type and schedule, use of inline filter, control and recording of station temperature.

4.7 Performance Audits

Performance audits will be conducted by personnel from Quality Assurance Section (QAS) of the ARB. Each measurement method will be audited on the project.

Performance audits are quantitative assessments of instrument operation that are accomplished by challenging site instruments with known audit standards. This section provides an overview of the key procedures that will be used. All audit procedures are described in detail in several appendices of ARB's "Audit Procedures Manual" (ARB, 1990, 1993a, 1993b, 1994a, 1994b, 1995a, 1995b, 1995c, 1995d, 1996a, 1996b). The procedures are also consistent with EPA guidelines for audits of gaseous and particulate samplers (40 CFR 58, App A, B, and E; EPA, 1984; EPA, 1986; EPA, 1987) and for meteorological instruments (EPA, 1989).

All audit results will be entered on QA Audit Station Data Worksheet forms and into an audit computer. Calculations are done by the computer and by hand for verification. Preliminary results will be summarized in reports for each measurement issued to the site operator at the conclusion of the audit. For gas analyzers, the reports will present the audit concentrations, the instrument responses, and the percent differences. Instrument performance will be assessed by comparing the percent differences to EPA criteria as shown in Table 4-5. For meteorological equipment, the reports will present the expected instrument responses, the actual instrument responses, and their differences. Instrument performance will be assessed by comparing the differences to the EPA criteria as shown in Table 4-5. For those instruments that exceed the criteria, the auditor will issue an Air Quality Data Action (AQDA). The site operator will be required to respond to the AQDA by detailing the actions done to correct instrumental problems found during the audit.

Table 4-5a
Audit Criteria - Continuous Gas Analyzers

Quantity	Measure	Excellent	Satisfactory	Unsatisfactory
Difference	Percent	0 - ± 5	$\pm(5 - 15)$	$<-15, >15$

Table 4-5b
Audit Criteria - Meteorological Sensors

Sensor	Satisfactory Limits
Wind Speed	± 0.25 m/s for $WS \leq 5.00$ m/s $\pm 5\%$ value for $WS > 5.00$ m/s not to exceed 2.5 m/s
Wind Speed (starting threshold)	< 0.5 m/s
Wind Direction	± 5 degrees relative to True North
Wind Direction (starting threshold)	< 0.5 m/s
Temperature	± 0.5 °C
Dew Point	± 1.5 °C
Dew Point (in fog)	± 0.5 °C
Solar Radiation	greater of $\pm 5\%$ or ± 25 w/m ²
Pressure	± 10 mb (± 7.5 mmHg)

4.7.1 Ozone

Performance audits of ozone analyzers will be conducted with one of two methods depending on the accessibility of the analyzers. In the first method, a Dasibi 1009 CP gas calibrator will be used as an ozone source and transfer standard. This instrument is contained in QAS's audit van. The Dasibi 1009 CP will generate known concentrations of ozone that will be supplied to the site analyzer through a 150 foot gas presentation line connected to the site inlet probe. The generated ozone will be measured by the Dasibi 1009 CP itself or by a separate API 400 Ozone analyzer. In the second method, a Dasibi 1008 PC portable ozone transfer standard will be transported to air monitoring site. The Dasibi 1008 PC will generate and measure concentrations of ozone to be introduced at the rear of the site analyzer.

The Dasibi 1009 CP and Dasibi 1008 PC instruments will generate ozone with an adjustable UV lamp. The concentration of the generated ozone will be measured with a UV photometer, either within the instrument or contained in a separate analyzer. For the van system, ozone-free air will be produced by an Aadco 737R pure air system in the audit van and a compressor capable of producing a constant 20 lpm supply of air at the end of the gas presentation tube. For the portable ozone standard, ozone-free air will be produced by passing ambient air through a cartridge of activated charcoal connected zero-air inlet of the instrument. Ozone concentrations measured by the transfer standards will be corrected to account for calibration factors for the standards, for the altitude correction factor if standard does have temperature/pressure correction, and for line loss in the gas presentation line.

Before starting the audit, the standard will be warmed up for at least one hour. It will be verified that all connections are made according to standard procedures. Instrument checks will be made and recorded.

The first audit point will be the response to ozone-free air. Three upscale ozone concentrations will be generated and delivered to the site analyzer and audit standard. The ranges of the concentrations will be 0.35 to 0.45 ppm, 0.15 to 0.20 ppm, and 0.03 to 0.08 ppm. A final response to zero air will be done after the 3 upscale points. For each concentration, the instruments will equilibrate for 30 minutes. Then ten consecutive readings of the ozone transfer standard will be recorded followed by ten consecutive readings from the data collection device site for the site analyzer. The average responses, differences, and percent differences will be calculated will be calculated for each audit point. The overall percent difference will be calculated for comparison to the audit criteria.

The ozone transfer standards are submitted to ARB's Standards Laboratory on a quarterly basis for recertification against the EPA-verified Primary Ozone Photometer. For a valid certification, it is required that the standard differ by less than $\pm 1.5\%$ from past certification values and the slope and intercept fall within one standard deviation of the last six certification equations.

4.7.2 Oxides of Nitrogen

Performance audits of NO/NO_x analyzers will be conducted using the Thru-the-Probe method as generated by instrumentation contained in QAS's audit van. Known quantities of National Institute of Standards and Technology (NIST) traceable gases will be diluted with 20 lpm of pure air will be

introduced to the site analyzer through a 150 foot gas presentation line connected to the site inlet probe. NO will be supplied from a cylinder of compressed air. NO₂ will be generated by the gas phase titration (GPT) of NO with ozone.

The audit standard will consist of a Dasibi 1009 CP dilution flow metering system, an Aadco 737R pure air system to generate NO-free dilution air (zero air) and compressor capable of supplying 20 lpm system, a superbblend cylinder of compressed gas containing a mixture of NO and CO (along with other gases) in NIST-traceable concentrations, a Thermoenvironmental (TEI) Carbon Monoxide analyzer, model 48, two cylinders of compressed gas with known amounts of CO, and one cylinder of compressed ultrapure air.

The Dasibi 1009 CP system also contains an ozone generator and second mixing chamber for the generation of NO₂. When ozone is mixed with NO, a GPT results which oxidizes some NO to NO₂. The generated NO₂ is calculated from the change in NO. The analyzer NO₂ readings and the converter efficiency are determined from the GPT.

Before starting the audit, the TEI 48 and dilution system will be warmed up for at least one hour. The CO analyzer will first be calibrated using the zero air cylinder and two CO cylinders. The CO concentration of the gas mixture generated by the Dasibi 1009 CP using the Aadco pure air and gas from the mixed gas cylinder will then be measured with the TEI 48. The dilution ratio of the generated audit sample will be calculated. The generated NO concentration will be calculated using the dilution ratio and the cylinder concentration.

The first audit point will introduce zero air to the site analyzer. The next steps will consist of introducing NO to the analyzer for the response of the NO and NO_x channels followed by the generation of NO₂ by GPT. A total of three NO₂ concentrations will be generated. A final low NO concentration will be generated. The ranges of concentration for NO, NO₂, and NO_x delivered to the site analyzer will be 0.35 to 0.45 ppm, 0.15 to 0.20 ppm, and 0.03 to 0.08 ppm. A final response to zero air will be done at the end of the audit.

Readings will be recorded from the primary data acquisition system. Sufficient time is allowed for the response to stabilize before recording any information. The measured values from the display, analog output, and data logger are compared to the audit concentration.

The dilution ratio will be calculated according to the equation:

$$\text{DILUTION RATIO} = \frac{\text{True CO Response (ppm)}}{\text{Superblend Cylinder CO Concentration (ppm)}}$$

The true concentration in ppm will be calculated from

$$\text{TRUE CONCENTRATION} = \text{Superblend Concentration} \times \text{Dilution Ratio}$$

The NO₂ channel response and the efficiency of the NO_x to NO converter will be tested with NO₂ generated in the GPT section of the dilution system. These tests are done at 3 different NO₂ and NO_x concentrations while the NO concentration remains between 80 to 100 ppb. NO gas with concentrations for the three points are near 450, 300, and 150 ppb. The responses of the NO and NO_x channels to this NO are recorded and adjusted by the linear regression equations relating instrument response to calibration concentration. Ozone is mixed with the NO to generate NO₂ concentrations near 350, 200, and 50 ppb which are introduced to the instrument. The responses of NO and NO_x are recorded and corrected for the calibration results.

The converter efficiency, Conv Eff, will be determined in the following steps:

$$\text{Conv Eff} = 100 \left(\frac{\Delta \text{NO} - \Delta \text{NO}_x}{\Delta \text{NO}} \right)$$

$$\Delta \text{NO} = (\text{Orig NO} - \text{Rem NO}) / \text{Slope NO}$$

$$\Delta \text{NO}_x = (\text{Orig NO}_x - \text{Rem NO}_x) / \text{Slope NO}_x$$

where: Orig NO is adjusted response of NO channel before ozone is mixed,
Rem NO is adjusted response of NO channel after ozone is mixed,
Orig NO_x is adjusted response of NO_x channel before ozone is mixed and
Rem NO_x is adjusted response of NO_x channel after ozone is mixed.

An overall converter efficiency will be calculated by averaging the efficiencies at the three levels. A converter efficiency less than 96% will require an AQDA.

4.7.3 Wind Speed

Wind speed sensor audit will consist of an evaluation of the starting threshold of each sensor and a comparison of sensor response to fixed inputs with a variable speed motor at several constant rotation rates (EPA, 1989d). If possible, sensors will be audited in place with tower standing or tilted down but with cups or propellers removed. The auditor will not climb the tower. The site operator will handle the sensor. The only sensors that have been calibrated recently will be audited. There will be some limitations on the audits because sensor accessibility and sensor type.

The condition of bearings and any dirt/materials in the anemometer shaft affects the starting threshold. The auditor will qualitatively evaluate these by rotating the sensor shaft by hand and feeling for drag and grinding. The starting threshold will be measured with a torque watch or torque disk to determine if the starting threshold is 0.5 mps or less.

Accuracy of the wind speed output of the system will be determined by replacing the anemometer or propeller with a variable speed anemometer drive (R.M. Young) to turn the shaft at rotation rates of 0, 60, 300, 600, and 1800 RPM. Instrument responses as registered by the DAS are compared to the manufacturer's speeds for these rotation rates. Differences between site and audit wind speeds are computed and compared to audit criteria.

4.7.4 Wind Direction

Wind direction sensor audits will consist of an evaluation of the threshold, orientation of cross arm, and instrument responses to known positions. If possible, the sensor will be audited in place on the tower. The auditor will not climb the tower. The site operator will handle the sensor. The only sensors that have been calibrated recently will be audited. There will be some limitations on the audits because of sensor accessibility and sensor type.

The auditor will check the starting threshold qualitatively in the same manner as for the wind speed sensor by feeling for drag and grinding. A quantitative measurement of starting threshold with a torque gauge can only be done under conditions of no air motion. With the sensor in a sheltered location, a gram gauge will be used to measure the starting threshold which should be less than 0.5 mps at a deflection of 10°.

Sensor orientation can be determined in several ways depending on the accessibility and type of sensor. In general, the audit will consist of holding the vane at several known positions covering the 360° circle and comparing the sensor reading to the position relative to true north. Angular bearings will be measured with a Brunton Pocket Transit on a tripod or Site Path Transit. Magnetic bearings from these transits will be converted to bearings relative to true North using current magnetic declination for the location obtained from the USGS GEOMAP program. The crossarm or sensor orientation will be measured. The vane orientation will be compared to known landmarks, the crossarm, or a degree orientation fixture such as the R.M. Young model 18212 or Met One models 040/044. The vane will be held in at least 4 different directions that are separated by approximately 90°. The output of the DAS for the 4 directions will be compared to the angle computed from bearing relative to true North. Differences between site and audit wind directions will be computed and compared to audit criteria.

4.7.5 Temperature

The accuracy of the temperature sensor will be evaluated one of two methods. If the sensor can be immersed in water, it will be removed from its shield and placed in water baths of three temperatures. The bath temperature will be measured with a calibrated audit thermocouple. The audit sensor will be a Digi-Sense J,K,T Thermocouple thermometer with a T-type thermocouple. Different bath temperatures will be obtained with ice, an immersion heater, and near ambient water. The audit comparison will consist of the difference between readings of the audit thermometer and the site sensor.

If the site sensor cannot be immersed in water, a side-by-side comparison will be made between the sensor and the audit thermocouple for a total of three readings. The sensors will be shaded to minimize the effect of solar radiation.

The audit thermometer and thermocouple are certified annually by a certification laboratory.

4.7.6 Relative Humidity/Dew Point

Accuracy of relative humidity/dew point sensor will be determined by placing the audit relative humidity sensor near the site sensor and obtaining 3 readings. The primary relative humidity probe will be a Rotronic Hygroskop GT-L relative humidity/temperature probe. This sensor will measure relative humidity directly. A secondary audit instrument will be an Environmental Tectonics Psychro-Dyne dry bulb/wet bulb psychrometer. The psychrometer measures wet- and dry-bulb temperature from which relative humidity and dew point can be calculated.

Since EPA's acceptance criteria for relative humidity is in terms of dew point temperature. The audit and site relative humidity will be converted to dew point using an expression for vapor pressure versus temperature for the Rotronic instrument or the psychrometric tables and/or psychrometric equation for the psychrometer. The difference between site and audit dew point will be computed and compared to the audit criteria.

The Rotronic probe is calibrated quarterly using salt solutions in a calibration device. Readings at 35, 50 and 80% relative humidity are obtained. The probe is returned to the manufacturer annually for recertification of the temperature sensor and a 35 and 80% relative humidity comparison.

4.7.8 Solar Radiation

Accuracy of solar radiation sensor will be determined by installing an audit pyranometer near the site sensor and obtaining several readings. The audit probe will be an Eppley model PSP precision spectral pyranometer with a LI-1000 data logger. The data logger will collect a series of 10-minute readings or readings integrated over a longer time period. The audit sensor will be placed as near the site sensor with the same exposure as possible. The difference between site and audit solar radiation will be computed and compared to audit criteria. The solar radiation audit will not be done if it is raining. The audit should be done near noontime if possible.

The audit pyranometer is returned annually to Eppley for recalibration against the companies standards.

4.8 Corrective Action

Corrective action will be initiated when a problem is identified. Problems may be identified during operations and/or during performance audits. The goal of corrective action is to remedy any problem before the affected quantity drops below the desired accuracy, precision, or completeness.

Problems found during the audits will be documented with the Air Quality Data Action (AQDA) mechanism. The site operator will be notified of problems during the audit. A response to the AQDA that covers the resolution of the problem will be required. The audits will be somewhat limited in determining operational problems since they will occur only once during the study.

During routine operations of the air quality and meteorological sites, data from the field sites will be reviewed on a daily schedule. This daily review will provide the primary initiation for corrective action when problems with the data are identified. The site operators will be secondary in identifying most problems except those by visual inspection.

Once a problem has been identified, it will be evaluated for most efficient way to fix that may involve the combined efforts of the data analyst, an instrument technician, and the site operator. The local supervisors, the study QA officer, and the study project manager will be informed of the problem, and later its resolution, through verbal and written notification. This will documents the problem, its resolution, and the effect on the particular quantity and the project in general.

4.9 Data Acquisition and Processing

The individual agencies and other participants in the field project are responsible for acquiring and processing data from their networks. In general, all procedures meet the requirements and guidelines of EPA (40 CFR 58, Appendices A and B; Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I, II, and IV). The objective of the data reduction and validation effort is a quality assured data base monitoring data in a consistent format.

Continuous data are collected by data acquisition systems (DAS) in the field at the agency sites and at the supplemental sites. The DAS samples the outputs from the instruments serially at fixed intervals and converts analog voltage signals to digital numbers for processing. Each hour, it computes hourly averaged data as scalar averages. Day and time of sample are collected also. Meteorological data may also include hourly and 15-minute averages are computed with temperature and relative humidity as scalar averages and winds as average scalar wind speed and unit vector wind direction. The standard deviation of the wind direction may be computed using the Yamartino method over 15-minute segments with an hourly averaged sigma theta computed as the root-mean-square value of the four 15-minute averages. Each record stored by the DAS is identified with a date and time. The time collected by most data loggers is time at the end of the sample period. The time associated with specific data records, beginning or ending, needs to be specified in the final data product.

At many sites, the DAS commands the site calibration system to perform daily automated zero/span checks of the instruments.

At many sites, averaged air quality and meteorological data and automated calibration data are retrieved automatically from the field each night by telephone and modem. At some agencies and for supplemental sites, these data are automatically screened for anomalies that are flagged for further investigation. The screening routines check for outliers, instrument problems, and data system problems. They can test for data that exceed set minima, maxima, and rate-of-change values. For the supplemental sites, reports from the screening programs will be available for review the next day. Data

are entered into a raw data base as they are received. This data base is saved in its original form and noted as such to assure that it could be obtained again if necessary. Subsequent data bases are updated as processing proceeds.

All site documentation are sent from the field to the operations office at least once a month. This includes site logs, checklist logs, zero/span checks, and multipoint calibration results. The ancillary site data are logged in and made available for use during data processing and validation.

4.10 Data Validation

All data are reviewed before use, starting with observations and reports from the site operators and continuing with the review of logs, checklists, and data. All flagged or anomalous data are investigated. All data are retained unless substantial evidence is available for their deletion.

For air quality data, zero and span check data are reviewed as an integral part of the process. Data for which the span response deviates by more than 25% or the zero by more than 25 ppb from expected values are invalidated. Data for which the span response deviates by 15 to 25% are adjusted using correction factors obtained for zero/span and calibration data.

All changes resulting from reviewing documentation are made directly on the raw data report and comments added as required. Raw data reports are reviewed to see that outliers have been corrected, replaced by missing data code if deleted, or checked as valid. When raw data are completely checked, corrected, and approved, changes are made to the data base and any necessary correction factors applied.

For supplemental sites, a data report will be generated that describes the data collected including units and lists missing data.

4.11 Data Archival

Data from the Air Pollution Control Districts are archived in AIRS format and are submitted to ARB and EPA. Data from the supplemental sites will also be archived in AIRS format and submitted to ARB.